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(54) **LUMINESCENT ELEMENT, PREPARATION METHOD THEREOF AND LUMINESCENCE METHOD**

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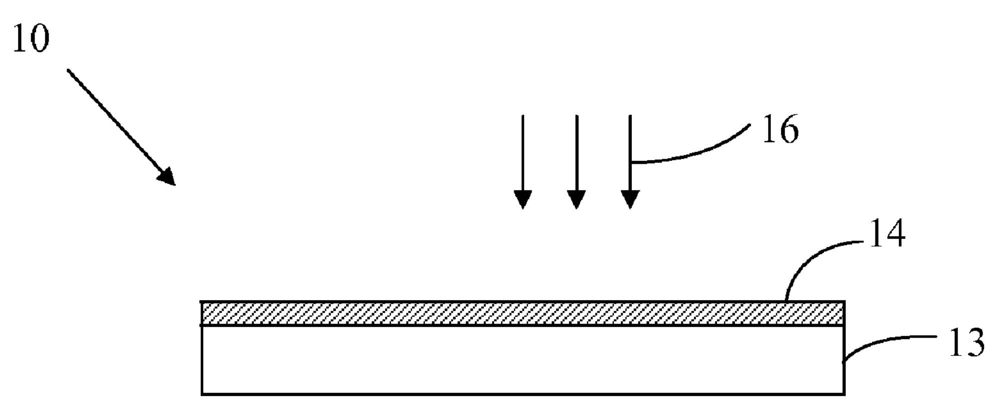
(57) **ABSTRACT**

A luminescent element comprises: a luminescent substrate; and a metal layer with a metal microstructure formed on a surface of the luminescent substrate; the luminescent substrate comprises luminescent materials with a chemical composition of Zn_2SiO_4:Mn. A preparation method of a luminescent element and a luminescence method are also provided. The luminescent element has good luminescence homogeneity, high luminescence efficiency, good luminescence stability and simple structure, and can be used in luminescent device with ultrahigh brightness.

9 Claims, 4 Drawing Sheets



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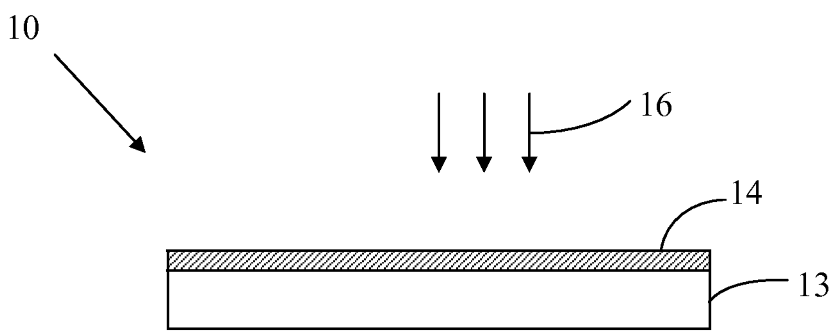

FIG. 1

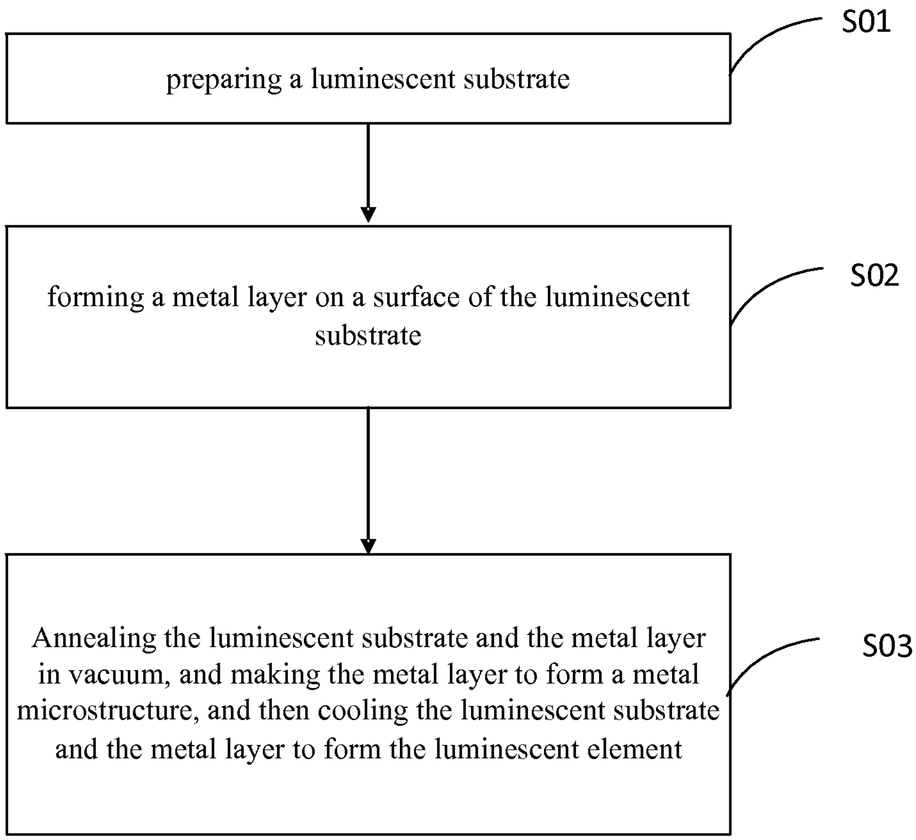
preparing a luminescent substrate
S01
forming a metal layer on a surface of the luminescent substrate
S02
Annealing the luminescent substrate and the metal layer in vacuum, and making the metal layer to form a metal microstructure, and then cooling the luminescent substrate and the metal layer to form the luminescent element
S03

FIG. 2

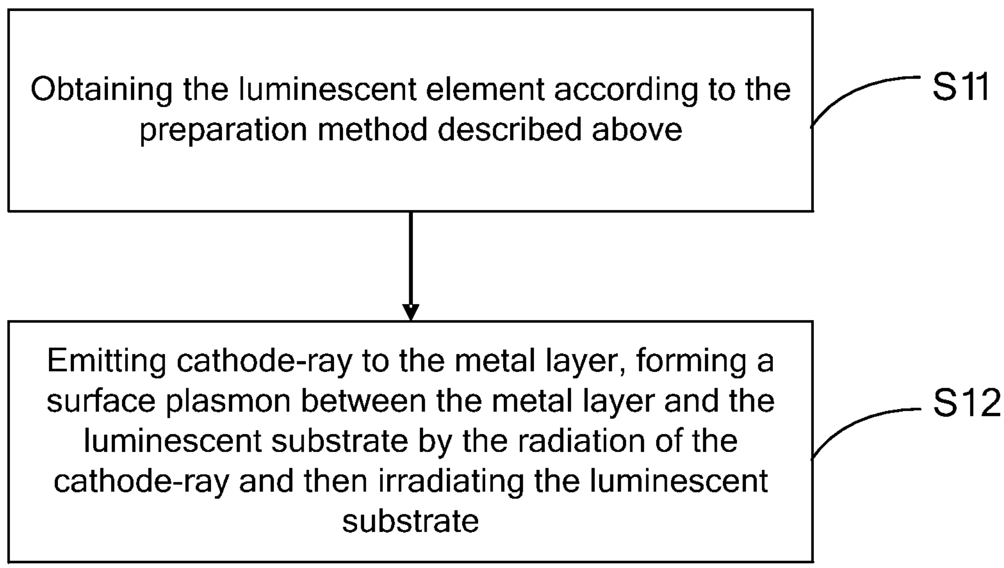
Obtaining the luminescent element according to the preparation method described above
S11
Emitting cathode-ray to the metal layer, forming a surface plasmon between the metal layer and the luminescent substrate by the radiation of the cathode-ray and then irradiating the luminescent substrate
S12

FIG. 3

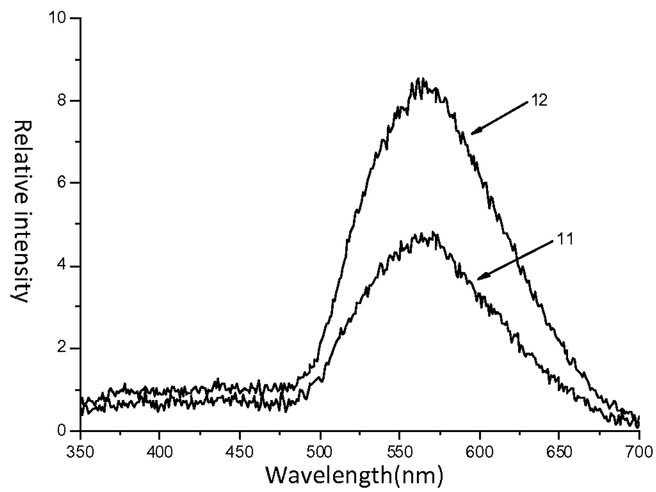
10
8
6
4
2
0
Relative intensity
350
400
450
500
550
600
650
700
Wavelength(nm)
12
11

FIG. 4

LUMINESCENT ELEMENT, PREPARATION METHOD THEREOF AND LUMINESCENCE METHOD

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a national stage of International Patent Application Serial No. PCT/CN2009/073517, filed Aug. 26, 2009, which is hereby incorporated by reference in the present disclosure in its entirety.

FIELD OF THE INVENTION

The present disclosure relates to luminescent materials, and more particularly relates to a luminescent element including a glass substrate made of luminescent material, preparation method thereof and luminescence method.

BACKGROUND OF THE INVENTION

The conventional materials used as luminescent substrate include phosphor, nanocrystal, glass, etc. Comparing to the crystal and phosphor, the glass is transparent, rigid, and has excellent chemical stability and superior luminescent performance. In addition, the glass can be easily machined into products with various shapes, which shows potential for application in display devices or luminescent light sources.

For example, in vacuum microelectronics, field emission devices usually use luminescent substrate as illuminant, which has shown a wide prospect in illumination and display techniques and draws a lot attention to domestic and foreign research institutes. The working principle of the field emission device is that, in vacuum, the anode applies a positive voltage to the field emissive arrays (FEAs) to form an accelerating electric field, electron emitted from the cathode accelerating bombards the luminescent material on the anode plate to irradiate. The field emission device has a wide operating temperature range (−40° C.~80° C.), short corresponding time (<1 ms), simple structure, low energy consumption, and meets the environmental protection requirements. Furthermore, materials such as the phosphor, luminescent substrate, luminescent film, etc can be served as luminescent material in field emission device, however, they all suffer from serious problems of low luminous efficiency, thus significantly limit the application of the field emission device, especially in the application of illumination.

SUMMARY OF THE INVENTION

In one aspect of the present disclosure, a luminescent element with a high luminescent homogeneity, high luminous efficiency, good stability, simple structure and a preparation method with a simple process and low cost are desired.

In another aspect of the present disclosure, a luminescence method of the luminescent element with simple operation, good reliability, and improving luminous efficiency is also desired.

A luminescent element includes: a luminescent substrate; and a metal layer with a metal microstructure formed on a surface of the luminescent substrate; wherein the luminescent substrate has a chemical composition of Zn_2SiO_4:Mn.

A preparation method of a luminescent element includes: preparing a luminescent substrate, wherein the luminescent substrate includes luminescent materials with a chemical composition of Zn_2SiO_4:Mn; forming a metal layer on a surface of the luminescent substrate, and annealing the luminescent substrate and the metal layer in vacuum to form a metal microstructure of the metal layer, and then cooling the luminescent substrate and the metal layer to form the luminescent element.

A luminescence method of a luminescent element includes: obtaining the luminescent element according to the preparation method described above; and emitting cathode-ray to the metal layer, forming a surface plasmon between the metal layer and the luminescent substrate by the radiation of the cathode-ray and then irradiating the luminescent substrate.

In the present disclosure described above, the metal layer with a metal microstructure is formed on a surface of the luminescent substrate, and irradiated by the cathode-ray, a surface plasmon can be formed between the metal layer and the luminescent substrate. Due to the surface plasmon effect, the internal quantum efficiency of the luminescent substrate is highly increased, and the spontaneous emission of the luminescent substrate is highly increased, so that the luminous efficiency of the luminescent substrate is improved and the low efficiency problem of the luminescent materials is overcome. Accordingly, in the luminescence method of the luminescent element, once emitting cathode-ray to the metal layer, the surface plasmon will be formed between the metal layer and the luminescent substrate, thus improving the luminous efficiency and reliability. The luminescent element has a simple two-layer structure for including the luminescent substrate and the metal layer. In addition, there is a uniform interface formed between the luminescent substrate and the metal layer, so that an excellent luminescent homogeneity and stability is achieved. In the luminescence method of the luminescent element, once emitting cathode-ray to the metal layer, the surface plasmon will be formed between the metal layer and the luminescent substrate, thus improving the luminous efficiency and reliability of the luminescent substrate.

The preparation method of the luminescent element of the present disclosure, the luminescent element can be obtained by forming a metal layer on the luminescent substrate and annealing the luminescent substrate and the metal layer, thus the preparation method is simple and has a low cost. The luminescent element can be widely applied to luminescent devices with ultra-high brightness and high-speed motion, such as field emission display.

BRIEF DESCRIPTION OF THE DRAWINGS

The components in the drawings are not necessarily drawn to scale, the emphasis instead being placed upon clearly illustrating the principles of the present disclosure.

FIG. **1** is a schematic view of a luminescent element according to an embodiment of the present disclosure;

FIG. **2** is a flow chart of an embodiment of a preparation method of a luminescent element;

FIG. **3** is a flow chart of an embodiment of a luminescence method of using a luminescent element;

FIG. **4** is an emission spectrum of the luminescent element of Example 1 comparing with the luminescent substrate without the metal layer, the emission spectrum being tested by Shimadzu RF-5301PC spectrometer excited by cathode-ray of 5 KV accelerating voltage.

DETAILED DESCRIPTION

The disclosure is illustrated by way of example and not by way of limitation in the figures of the accompanying drawings in which like references indicate similar elements. It should be noted that references to "an" or "one" embodiment in this disclosure are not necessarily to the same embodiment, and such references mean at least one.

Referring to FIG. **1**, an embodiment of a luminescent element includes a luminescent substrate **13** and a metal layer **14** formed on a surface of the luminescent substrate **13**. The metal layer **14** has a metal microstructure, which may be called as micro-nano structure. In addition, the metal microstructure is aperiodic, i.e. composed of metal crystal in irregular arrangement.

In an embodiment of the present disclosure, the luminescent substrate **13** can be luminescent glass doped with luminescent materials with a chemical composition of Zn_2SiO_4:Mn, wherein the glass has a chemical composition of $20Na_2O$-$20BaO$-$30B_2O_3$-$30SiO_2$. The glass may made of glass powder with low melting point, but the glass is not limited to the material described above. The mass percentage of the luminescent materials with a chemical composition of Zn_2SiO_4:Mn in the luminescent substrate is 5%~35%.

In another embodiment of the present disclosure, the luminescent substrate **13** includes a transparent or translucent substrate and a luminescent film formed on the substrate with a chemical composition of Zn_2SiO_4:Mn, the metal layer **14** is formed on the luminescent film.

The metal layer **14** can be made of metals with excellent chemical stability, such as antioxidant and corrosion-resistant metals, or common metals. The metal layer **14** is preferably made of at least one metal selected from the group consisting of Au, Ag, Al, Cu, Ti, Fe, Ni, Co, Cr, Pt, Pd, Mg, and Zn, or more preferably made of at least one metal selected from the group consisting of Au, Ag, and Al. The metal layer **14** may be made of one metal or a composite metal. The composite metal may be an alloy of two or more than two metals described above. For example, the metal layer **14** may be an Ag/Al alloy layer or an Au/Al alloy layer, where the weight percent of Ag or Au is preferably more than 70%. The metal layer **14** has a thickness in a range of 0.5~200 nm, preferably 1~100 nm.

As a luminescent element, the luminescent element **10** can be widely applied to luminescent devices with ultra-high brightness and high-speed motion, such as field emission display, field emission light source, and large advertising display, etc. Take field emission display as an example, the anode applies a positive voltage to the field emission cathode to form an accelerating electric field, the cathode emits electron, i.e. cathode-ray **16** to the metal layer **14**, so that a surface plasmon is formed between the metal layer **14** and the luminescent substrate **13**. Due to the surface plasmon effect, the internal quantum efficiency of the luminescent substrate **13** is highly increased, and the spontaneous emission of the luminescent substrate is highly increased, so that the luminous efficiency of the luminescent substrate is improved and the low efficiency problem of the luminescent materials is overcome. In addition, since a metal layer is formed on the surface of the luminescent substrate **13**, a uniform interface is formed between the whole metal layer and the luminescent substrate **13**, thus improving the luminescent homogeneity.

Referring to FIG. **1** and FIG. **2**, a flow chart of an embodiment of a preparation method of a luminescent element is shown and includes following steps:

Step S**01**, the luminescent substrate **13** is prepared with a chemical composition of Zn_2SiO_4:Mn.

Step S**02**, the metal layer **14** is formed on a surface of the luminescent substrate **13**.

Step S**03**, the luminescent substrate **13** and the metal layer **14** are annealed in vacuum to form the metal microstructure of the metal layer **14**, and then the luminescent substrate **13** and the metal layer **14** are cooled to form the luminescent element **10**.

In step S**01**, the luminescent substrate **13** described above can have two structures: the first luminescent structure is luminescent glass doped with luminescent materials with a chemical composition of Zn_2SiO_4:Mn, the second luminescent structure is the luminescent film formed on the substrate with a chemical composition of Zn_2SiO_4:Mn. The preparation of the first luminescent structure includes: mixing the luminescent materials with a chemical composition of Zn_2SiO_4:Mn and glass powder; melting at a temperature of 1200° C.; cooling to ambient temperature, and obtaining the luminescent glass doped with luminescent materials with a chemical composition of Zn_2SiO_4:Mn. The glass powder has a chemical composition of $20Na_2O$-$20BaO$-$30B_2O_3$-$30SiO_2$. The luminescent materials with a chemical composition of Zn_2SiO_4:Mn may also be powder. Mixing the luminescent materials and the glass powder in accordance with the mass ratio of 1:19~7:13, and the luminescent materials accounted for 5%~35% of the mixture; melting the mixture at a temperature of 1200° C.; placing the mixture on steel plates and cooling the mixture to ambient temperature; and obtaining the luminescent substrate **13**.

The preparation of the second luminescent structure includes: forming a luminescent film on a surface of a transparent or translucent substrate, and the luminescent film has a chemical composition of Zn_2SiO_4:Mn. The luminescent film with a chemical composition of Zn_2SiO_4:Mn:Tb can be formed on the surface of the substrate by magnetron sputtering, electron beam evaporating, chemical vapor deposition, molecular beam epitaxy, pulsed laser deposition, or spray pyrolysis process.

As previously described, the metal layer **14** is formed by depositing metal source with excellent chemical stability, such as antioxidant and corrosion-resistant metals, or common metals. The metal layer **14** is preferably made of at least one metal selected from the group consisting of Au, Ag, Al, Cu, Ti, Fe, Ni, Co, Cr, Pt, Pd, Mg, and Zn, or more preferably made of at least one metal selected from the group consisting of Au, Ag, and Al. In step S**02**, the metal layer **14** is formed on the surface of the luminescent substrate **13** via PVD or CVD, such as but not limited to sputtering or evaporation, with at least one metal described above. The metal layer **14** has a thickness in a range of 0.5~200 nm, preferably 1~100 nm.

In step S**03**, after the formation of the metal layer **14** on the luminescent substrate **13**, the metal layer **14** and the luminescent substrate **13** are annealed at a temperature in a range of 50~650° C. for 5 minutes to 5 hours and cooled to ambient temperature. The preferred anneal temperature is in a range of 100~600° C., and the preferred anneal time is in a range of 15 minutes to 3 hours.

Referring to FIG. **1** and FIG. **3**, a flow chart of a luminescence method of the luminescent element is shown and includes following steps:

Step S**11**, the luminescent element **10** is obtained according to the previously described preparation method.

Step S**12**, cathode-ray **16** is emitted to the metal layer **14**. A surface plasmon is formed between the metal layer **14** and the luminescent substrate **13** by the radiation of the cathode-ray **16** and thus irradiating the luminescent substrate **13**.

The luminescent element **10** has features of structure and composition as previously described. In application, the step S**12** can be implemented by field emission display or illumination light source. In vacuum, the anode applies a positive voltage to the field emission cathode to form an accelerating electric field, so that the cathode emits cathode-ray **16**. Excited by the cathode-ray **16**, electron beam will penetrate the metal layer **14** and irradiate the luminescent substrate **13**. During such process, a surface plasmon is formed between the metal layer **14** and the luminescent substrate **13**. Due to the surface plasmon effect, the internal quantum efficiency of the luminescent substrate **13** is highly increased, and the spontaneous emission of the luminescent substrate is highly increased, so that the luminous efficiency of the luminescent substrate is improved.

As described above, the luminescent substrate **13** has two structures, based on the first structure, the electron beam penetrate the metal layer **14** and irradiate Zn_2SiO_4:Mn in the luminescent glass. During such process, a surface plasmon is formed between the surface of the luminescent glass doped with Zn_2SiO_4:Mn and the metal layer **14**, and irradiates Zn_2SiO_4:Mn. Based on the second structure the electron beam penetrate the metal layer **14** and irradiate the luminescent film with a chemical composition of Zn_2SiO_4:Mn. During such process, a surface plasmon is formed between the surface of the luminescent film with a chemical composition of Zn_2SiO_4:Mn and the metal layer **14**, and irradiates Zn_2SiO_4:Mn.

Surface plasmon (SP) is a wave spread along the interface between the metal and medium, whose amplitude exponentially decay with the increase of the distance away from the interface. When changing a surface structure of the metal, the feature, dispersion relationship, excitation mode, coupling effect of the surface plasmon polaritons (SPPs) will be significantly changed. The electromagnetic field caused by the SPPs can not only constrain the spread of the light wave in sub-wavelength size structure, but also can produce and manipulate the electromagnetic radiation from light frequency to microwave band, thus active manipulation of the light spread is implemented. Accordingly, the present embodiment uses the excitation of the SPPs to increase the optical density of the luminescent substrate and to enhance spontaneous emission velocity of the luminescent substrate. In addition, the coupling effect of the surface plasmon can be used, when the luminescent substrate irradiates, sympathetic vibration phenomena occurs, thus the internal quantum efficiency of the luminescent substrate is highly increased, so that the luminous efficiency of the luminescent substrate is improved.

A plurality of examples are described to illustrate the different compositions and preparation methods of the luminescent element, and their performances. In the following embodiments, the luminescent materials with a chemical composition of Zn_2SiO_4:Mn can be market sale.

Example 1

Phosphor with a composition of Zn_2SiO_4:Mn and glass powder are mixed in accordance with the mass ratio 1:4, and melted to obtain a luminescent glass doped with luminescent materials with the composition of Zn_2SiO_4:Mn. The glass powder has a chemical composition of $20Na_2O$-$20BaO$-$30B_2O_3$-$30SiO_2$. A silver layer with a thickness of 2 nm is deposited on a surface of the luminescent glass via a magnetron sputtering equipment. The luminescent glass and the silver layer are annealed at a temperature of 300° C. for half an hour in vacuum with the vacuum degree $<1\times10^{-3}$ Pa and cooled to ambient temperature, thus a luminescent element is obtained.

Spectrum of the luminescent element obtained above is tested. The prepared luminescent element is bombarded by cathode-ray from an electron gun, and the electron beam penetrates the metal layer and irradiates the luminescent glass doped with Zn_2SiO_4:Mn, thus an emission spectrum shown in FIG. **4** is obtained. As shown in FIG. **4**, luminescent materials are green luminescent materials, curve **11** represents an emission spectrum of a luminescent substrate without the metal layer; curve **12** represents an emission spectrum of the luminescent element with the metal layer of Example 1. As shown in FIG. **4**, since a surface plasmon is formed between the metal layer and the luminescent substrate, comparing to the luminescent substrate without the metal layer, the luminescent element with the metal layer of Example 1 has a luminescence integral intensity 2 times as that of the luminescent substrate without the metal layer in a wavelength of 350~700 nm, accordingly, the luminescent performance is greatly improved.

Other Examples have the similar emission spectrums and luminescent performance as Example 1, which will not be described later.

Example 2

Phosphor with a composition of Zn_2SiO_4:Mn and glass powder are mixed in accordance with the mass ratio 1:19, and melted to obtain a luminescent glass doped with luminescent materials with the composition of Zn_2SiO_4:Mn. The glass powder has a chemical composition of $20Na_2O$-$20BaO$-$30B_2O_3$-$30SiO_2$. A gold layer with a thickness of 0.5 nm is deposited on a surface of the luminescent glass via a magnetron sputtering equipment. The luminescent glass and the gold layer are annealed at a temperature of 200° C. for an hour in vacuum with the vacuum degree $<1\times10^{-3}$ Pa and cooled to ambient temperature, thus a luminescent element is obtained.

Example 3

Phosphor with a composition of Zn_2SiO_4:Mn and glass powder are mixed in accordance with the mass ratio 7:13, and melted to obtain a luminescent glass doped with luminescent materials with the composition of Zn_2SiO_4:Mn. The glass powder has a chemical composition of $20Na_2O$-$20BaO$-$30B_2O_3$-$30SiO_2$. A aluminum layer with a thickness of 200 nm is deposited on a surface of the luminescent glass via a magnetron sputtering equipment. The luminescent glass and the aluminum layer are annealed at a temperature of 500° C. for five hours in vacuum with the vacuum degree $<1\times10^{-3}$ Pa and cooled to ambient temperature, thus a luminescent element is obtained.

Example 4

A 1×1 cm^2, double-sided polished sapphire substrate is selected. A luminescent film with a composition of Zn_2SiO_4:Mn is formed on the sapphire substrate by magnetron sputtering, and a magnesium layer with a thickness of 100 nm is deposited on the surface of the luminescent film via an electron beam evaporation equipment. The luminescent film and the magnesium layer are annealed at a temperature of 650° C. for five minutes in vacuum with the vacuum degree $<1\times10^{-3}$ Pa and cooled to ambient temperature, thus a luminescent element is obtained.

Example 5

A 1×1 cm^2, double-sided polished magnesium oxide substrate is selected. A luminescent film with a composition of Zn_2SiO_4:Mn is formed on the magnesium oxide substrate by molecular beam epitaxy, and a palladium layer with a thickness of 1 nm is deposited on the surface of the luminescent film via an electron beam evaporation equipment. The luminescent film and the palladium layer are annealed at a temperature of 100° C. for three hours in vacuum with the vacuum degree $<1\times10^{-3}$ Pa and cooled to ambient temperature, thus a luminescent element is obtained.

Example 6

A 1×1 cm^2, double-sided polished magnesium oxide substrate is selected. A luminescent film with a composition of Zn_2SiO_4:Mn is formed on the magnesium oxide substrate by spray pyrolysis process, and a platinum layer with a thickness of 5 nm is deposited on the surface of the luminescent film via an electron beam evaporation equipment. The luminescent film and the platinum layer are annealed at a temperature of 450° C. for fifteen minutes in vacuum with the vacuum degree $<1\times10^{-3}$ Pa and cooled to ambient temperature, thus a luminescent element is obtained.

Example 7

A 1×1 cm^2, double-sided polished quartz substrate is selected. A luminescent film with a composition of Zn_2SiO_4:Mn is formed on the quartz substrate by magnetron sputtering, and a iron layer with a thickness of 20 nm is deposited on the surface of the luminescent film via an electron beam evaporation equipment. The luminescent film and the iron layer are annealed at a temperature of 50° C. for five hours in vacuum with the vacuum degree $<1\times10^{-3}$ Pa and cooled to ambient temperature, thus a luminescent element is obtained.

Example 8

A 1×1 cm^2, double-sided polished quartz substrate is selected. A luminescent film with a composition of Zn_2SiO_4:Mn is formed on the quartz substrate by magnetron sputtering, and a titanium layer with a thickness of 10 nm is deposited on the surface of the luminescent film via an electron beam evaporation equipment. The luminescent film and the titanium layer are annealed at a temperature of 150° C. for two hours in vacuum with the vacuum degree $<1\times10^{-3}$ Pa and cooled to ambient temperature, thus a luminescent element is obtained.

Example 9

A 1×1 cm^2, double-sided polished quartz substrate is selected. A luminescent film with a composition of Zn_2SiO_4:Mn is formed on the quartz substrate by magnetron sputtering, and a copper layer with a thickness of 50 nm is deposited on the surface of the luminescent film via an electron beam evaporation equipment. The luminescent film and the copper layer are annealed at a temperature of 200° C. for two and a half hours in vacuum with the vacuum degree $<1\times10^{-3}$ Pa and cooled to ambient temperature, thus a luminescent element is obtained.

Example 10

A 1×1 cm^2, double-sided polished quartz substrate is selected. A luminescent film with a composition of Zn_2SiO_4:Mn is formed on the quartz substrate by magnetron sputtering, and a zinc layer with a thickness of 150 nm is deposited on the surface of the luminescent film via an electron beam evaporation equipment. The luminescent film and the zinc layer are annealed at a temperature of 350° C. for half an hour in vacuum with the vacuum degree $<1\times10^{-3}$ Pa and cooled to ambient temperature, thus a luminescent element is obtained.

Example 11

A 1×1 cm^2, double-sided polished quartz substrate is selected. A luminescent film with a composition of Zn_2SiO_4:Mn is formed on the quartz substrate by magnetron sputtering, and a chromium layer with a thickness of 120 nm is deposited on the surface of the luminescent film via an electron beam evaporation equipment. The luminescent film and the chromium layer are annealed at a temperature of 250° C. for two hours in vacuum with the vacuum degree $<1\times10^{-3}$ Pa and cooled to ambient temperature, thus a luminescent element is obtained.

Example 12

A 1×1 cm^2, double-sided polished quartz substrate is selected. A luminescent film with a composition of Zn_2SiO_4:Mn is formed on the quartz substrate by magnetron sputtering, and a nickel layer with a thickness of 40 nm is deposited on the surface of the luminescent film via an electron beam evaporation equipment. The luminescent film and the nickel layer are annealed at a temperature of 80° C. for four hours in vacuum with the vacuum degree $<1\times10^{-3}$ Pa and cooled to ambient temperature, thus a luminescent element is obtained.

Example 13

A 1×1 cm^2, double-sided polished quartz substrate is selected. A luminescent film with a composition of Zn_2SiO_4:Mn is formed on the quartz substrate by magnetron sputtering, and a cobalt layer with a thickness of 180 nm is deposited on the surface of the luminescent film via an electron beam evaporation equipment. The luminescent film and the cobalt layer are annealed at a temperature of 400° C. for an hour in vacuum with the vacuum degree $<1\times10^{-3}$ Pa and cooled to ambient temperature, thus a luminescent element is obtained.

Example 14

Phosphor with a composition of Zn_2SiO_4:Mn and glass powder are mixed in accordance with the mass ratio 3:17, and melted to obtain a luminescent glass doped with luminescent materials with the composition of Zn_2SiO_4:Mn. The glass powder has a chemical composition of $20Na_2O$-20BaO-$30B_2O_3$-$30SiO_2$. A gold/aluminum layer with a thickness of 0.5 nm is deposited on a surface of the luminescent glass via a magnetron sputtering equipment. In the gold/aluminum layer, the gold is about 80 weight %, and the aluminum is about 20 weight %. The luminescent glass and the gold/aluminum layer are annealed at a temperature of 200° C. for an hours in vacuum with the vacuum degree $<1\times10^{-3}$ Pa and cooled to ambient temperature, thus a luminescent element is obtained.

Example 15

Phosphor with a composition of Zn_2SiO_4:Mn and glass powder are mixed in accordance with the mass ratio 3:7, and melted to obtain a luminescent glass doped with luminescent materials with the composition of Zn_2SiO_4:Mn. The glass powder has a chemical composition of $20Na_2O$-20BaO-$30B_2O_3$-$30SiO_2$. A silver/aluminum layer with a thickness of 15 nm is deposited on a surface of the luminescent glass via a magnetron sputtering equipment. In the silver/aluminum layer, the silver is about 90 weight %, and the aluminum is about 10 weight %. The luminescent glass and the silver/aluminum layer are annealed at a temperature of 200° C. for an hours in vacuum with the vacuum degree $<1\times10^{-3}$ Pa and cooled to ambient temperature, thus a luminescent element is obtained.

Example 16

A 1×1 cm^2, double-sided polished quartz substrate is selected. A luminescent film with a composition of Zn_2SiO_4:Mn is formed on the quartz substrate by magnetron sputtering, and a silver/aluminum layer with a thickness of 10 nm is deposited on the surface of the luminescent film via an electron beam evaporation equipment. In the silver/aluminum layer, the silver is about 80 weight %, and the aluminum is about 20 weight %. The luminescent film and the silver/aluminum layer are annealed at a temperature of 150° C. for two hours in vacuum with the vacuum degree $<1\times10^{-3}$ Pa and cooled to ambient temperature, thus a luminescent element is obtained.

Example 17

A 1×1 cm^2, double-sided polished magnesium oxide substrate is selected. A luminescent film with a composition of Zn_2SiO_4:Mn is formed on the magnesium oxide substrate by magnetron sputtering, and a gold/aluminum layer with a thickness of 10 nm is deposited on the surface of the luminescent film via an electron beam evaporation equipment. In the gold/aluminum layer, the gold is about 90 weight %, and the aluminum is about 10 weight %. The luminescent film and the gold/aluminum layer are annealed at a temperature of 150° C. for two hours in vacuum with the vacuum degree $<1\times10^{-3}$ Pa and cooled to ambient temperature, thus a luminescent element is obtained.

In Examples described above, the metal layer **14** with a metal microstructure is formed on a surface of the luminescent substrate **13**, and irradiated by the cathode-ray, a surface plasmon can be formed between the metal layer **14** and the luminescent substrate **13**. Due to the surface plasmon effect, the internal quantum efficiency of the luminescent substrate **13** is highly increased, and the spontaneous emission of the luminescent substrate is highly increased, so that the luminous efficiency of the luminescent substrate is improved and the problem of low efficiency of the luminescent materials is overcome. In the luminescence method of the luminescent element, once emitting cathode-ray to the metal layer **14**, the surface plasmon will be formed between the metal layer **14** and the luminescent substrate **13**, thus improving the luminous efficiency and reliability. The luminescent element **10** has a simple two-layer structure for including the luminescent substrate **13** and the metal layer **14**. In addition, there is a uniform interface formed between the luminescent substrate **13** and the metal layer **14**, so that an excellent luminescent homogeneity and stability is achieved. In a luminescence method using the luminescent element, once emitting cathode-ray to the metal layer **14**, the surface plasmon will be formed between the metal layer **14** and the luminescent substrate **13**, thus improving the luminous efficiency and reliability of the luminescent substrate **13**.

In the embodiment of the preparation method of the luminescent element, the luminescent element can be obtained by forming a metal layer on the luminescent substrate and annealing the luminescent substrate and the metal layer, thus the preparation method is simple and has a low cost. The luminescent element can be widely applied to luminescent devices with ultra-high brightness and high-speed motion, such as field emission display.

Although the invention has been described in language specific to structural features and/or methodological acts, it is to be understood that the invention defined in the appended claims is not necessarily limited to the specific features or acts described. Rather, the specific features and acts are disclosed as sample forms of implementing the claimed invention.

What is claimed is:

1. A luminescent element, comprising:
a luminescent substrate; and
a metal layer with a metal microstructure formed on a surface of the luminescent substrate,
wherein the luminescent substrate comprises luminescent materials with a chemical composition of Zn_2SiO_4:Mn,
wherein the luminescent substrate is luminescent glass doped with luminescent materials with a chemical composition of Zn_2SiO_4:Mn, and
wherein the luminescent glass has a chemical composition of $20Na_2O$-$20BaO$-$30B_2O_3$-$30SiO_2$.

2. The luminescent element according to claim **1**, wherein the mass percentage of the luminescent materials with a chemical composition of Zn_2SiO_4:Mn in the luminescent substrate is 5%~35%.

3. The luminescent element according to claim **1**, wherein the luminescent substrate comprises a transparent or translucent substrate and a luminescent film formed on the substrate with a chemical composition of Zn_2SiO_4:Mn, and the metal layer is formed on the luminescent film.

4. The luminescent element according to claim **1**, wherein the metal layer is made of at least one metal selected from the group consisting of Au, Ag, Al, Cu, Ti, Fe, Ni, Co, Cr, Pt, Pd, Mg, and Zn.

5. The luminescent element according to claim **1**, wherein the metal layer has a thickness in a range of 0.5 nm-200 nm.

6. A preparation method of a luminescent element, comprising:
mixing luminescent materials with a chemical composition of Zn_2SiO_4:Mn and glass powder to form a mixture;
melting the mixture at a temperature of 1200° C.;
cooling the melted mixture to ambient temperature to obtain a luminescent substrate, wherein the luminescent substrate is a luminescent glass doped with the luminescent materials with a chemical composition of Zn_2SiO_4:Mn, wherein the glass powder has a chemical composition of $20Na_2O$-$20BaO$-$30B_2O_3$-$30SiO_2$;
forming a metal layer on a surface of the luminescent substrate;
annealing the luminescent substrate and the metal layer in vacuum to form a metal microstructure of the metal layer; and
cooling the luminescent substrate and the metal layer to form the luminescent element.

7. A luminescence method of a luminescent element, comprising:
preparing a luminescent substrate, wherein the luminescent substrate comprises luminescent materials with a chemical composition of Zn_2SiO_4:Mn;
forming a metal layer on a surface of the luminescent substrate;
annealing the luminescent substrate and the metal layer in vacuum to form a metal microstructure of the metal layer;
cooling the luminescent substrate and the metal layer to form the luminescent element;
emitting cathode-ray to the metal layer;
forming a surface plasmon between the metal layer and the luminescent substrate by the radiation of the cathode-ray; and
irradiating the luminescent substrate.

8. The luminescence method of claim **7**, wherein the preparation of the luminescent substrate comprises:

mixing the luminescent materials with a chemical composition of Zn_2SiO_4:Mn and glass powder to form a mixture;

melting the mixture at a temperature of 1200° C.;

cooling the melted mixture to ambient temperature; and

obtaining a luminescent glass doped with luminescent materials with a chemical composition of Zn_2SiO_4:Mn, wherein the glass powder has a chemical composition of $20Na_2O$-$20BaO$-$30B_2O_3$-$30SiO_2$.

9. The luminescence method of claim **7**, wherein the preparation of the luminescent substrate comprises:

forming a luminescent film on a surface of a transparent or translucent substrate, wherein the luminescent film has a chemical composition of Zn_2SiO_4:Mn.

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